Specification

DROPLET SPRAYING DEVICE AND METHOD OF MANUFACTURING THE SPRAYING DEVICE

Field of the Invention

The present invention relates to a liquid-drop spraying device placed in a raw material fuel discharging device which is used for a variety of machines treating the above described liquid or acting by discharging a liquid raw material or fuel.

Description of the Prior Art

~~A conventional liquid drop spraying device is a~~ liquid drop spraying device performing spraying by discharging a liquid-drop from discharging outlet due to the volume changes of a plurality of pressure rooms, which are connected to the common pass via inlets provided in these respective pressure rooms, piezo-electric / electrostrictive element is formed on one portion of wall in every pressure room and the relevant element is changed in shape by voltage signal applied to the relevant element. Then, in the case where a large amount of a liquid is discharged by use of a raw material fuel discharging device, a large number of discharging unit providing one piezo-electric / electrostrictive element in one pressure room have been placed on a liquid-drop spraying device or discharging period has been made longer. In such a liquid-drop spraying device, for example, as a fuel ejecting device densely arraying a large number of ejecting elements having a nozzle in a staggered arrangement ~~on the entire inside wall surface of inlet manifold in carbureter~~

of internal combustion engine, there is a fuel ejecting device published in Japanese Unexamined Patent Publication No. 54-90116 (1979) official gazette. Its cavity of each ejecting element is made on the manifold wall so that nozzle is located inside, and piezo-electric vibrator is placed on the outside surface via a thin metal plate. Then, each ejecting element is connected to a fuel tank via passage equipped with a check valve, a liquid within a cavity is ejected from the nozzle towards the inside of a manifold by the vibration of the piezo-electric vibrator.

However, even if a liquid-drop spraying device is provided with a large number of discharging units in order to increase the discharging amount, since displacement amount of piezo-electric / electrostrictive element is small and an area where discharging units are placed is limited, depending on the use, there have been cases that a sufficient discharging amount cannot be sprayed.

Moreover, that a large number of discharging units are provided corresponding to the required discharging amount, and that piezo-electric / electrostriction element of small amount of displacement is integrally laminate molded with a pressure room to perform precise alignment on the pressure room, are factors that raise the manufacturing cost.

Furthermore, that a pressure room and piezo-electric / electrostriction element are integrally sintered and formed is means for suppressing the manufacturing cost, however, there has been a limitation that materials for vibration source increasing and reducing the pressure of a pressure room are limited.

Disclosure of the Invention

Accordingly, in order to resolve the above described problem, the present inventor provides a liquid-drop spraying device capable of spraying a liquid from a discharging outlet by vibration sources such as piezo-electric / electrostrictive element and others which are provided to a liquid sump with two or more pressure rooms or pass or etc. by the number less than the number of the pressure rooms, and increase and reduce the pressure to them in the liquid sump.

In the present invention of claim 1 out of the invention as claimed in the application concerned, a liquid-drop spraying device has a liquid sump consisted of the pressure room equipped with at least one discharging outlet, and a pass connected to one or more pressure rooms via an inlet and supplying a liquid, and a vibration source causing the relevant liquid sump to change the volume, and in which at least two or more relevant pressure rooms are provided to the relevant vibration source. Owing to this, not only a liquid can be discharged from a plurality of discharging outlets by one action only by driving one vibration source, but also a vibration source itself becomes larger, the selection of design is more various than conventional one, and a larger displacement can be generated.

Now, a liquid sump is designed so that it does not have a valve structure in an inlet coupling a pressure room equipped with at least one discharging outlet and a pass supplying a liquid to one or more pressure rooms, when a liquid is discharged since pressure variation by increasing and decreasing the pressure occurs in pressure rooms, a large amount of back flow is not generated from the inlet provided in narrow and small area to

the pass. Moreover, it will be good that vibration source is a member vibrating a predetermined vibration, and vibration source includes also general vibration source such as solenoid coil and the like besides one which electric signal is converted in direct to physical operation as piezo-electric / electrostriction element. Particularly, piezo-electric / electrostriction element is excellent in its quick response, large force and accuracy of vibration amount, and it is preferable. Moreover, a structure of a piezo-electric / electrostriction element is not limited to structures such as a single layer element forming electrodes on its both sides and a composite element enlarging displacement in space by combining with other elastic materials and the like, an actuator laminated molding piezo-electric / electrostrictive elements and electrodes over multiplayer is suitable from the viewpoint of its low voltage driving ability and large displacement ability.

Moreover, the invention of claim 2 is a liquid-drop spraying device in which a liquid sump and a vibration source are separate bodies. Owing to this, the vibration source can be individually formed separated from the liquid sump, for example, the vibration source can be formed by a material enlarging displacement amount, separated from the liquid sump. Moreover, if the material of the liquid sump is, for example, metal, its toughness is enhanced, durability can be increased. And since material components forming the vibration source is not diffused to side of a substrate equipped with the liquid sump, the material of the substrate is stable and durability is further enhanced.

Now, as for the relationship between the vibration source and the liquid sump, it is not needed to be contacted with each other in a constant state, it will be good at least vibrating portion or movable portion is contacted for the transition of vibration even if they are apart at the certain interval. However, in the case where the vibration is transmitted to a plurality of pressure rooms at the same time by the same vibration source, it is preferable they are contacted with each other even in a constant state. Concretely, they are retained in a contacted state by mechanical adjustment means such as spring, screw and the like. Moreover, the liquid sump and the vibration source which are separate bodies can be also fixed by adhesive, filler added adhesive, thermal diffusion method and the like. Furthermore, the movable section of the vibration source is not necessarily required to be directly neighboring to or contacted with the liquid sump, it is sufficient to be contacted with the vibration source via at least one relaying member transmitting vibration to the liquid sump, in this case, since adjustment can be carried out by the relaying member, alignment of the vibration source becomes unnecessary, the reduction of a number of the vibration sources is possible, and cost reduction is contemplated.

Moreover, the invention of claim 3 is a liquid-drop spraying device in which one portion of the vibration source is fixed on fixation section such as base frame and the like, at least one portion of other vibration portions or movable portions is contacted with a liquid sump. Owing to this, the vibration of the vibration source is more efficiently transmitted

to the liquid sump, and spraying efficiency is enhanced.

Moreover, the invention of claim 4 is a liquid-drop spraying device in which at least one surface out of the contact surfaces on which the vibration source and the pressure room are contacted with each other is in a convex shape. Now, a contact surface is referred to a vibration transmitting surface for the vibration source and a vibration transmitted surface for the pressure room to cause volume change in the pressure room by the vibration source, and in the case where at least one of them is in a convex shape toward outside, the other will be good in any shape of a convex shape, a smooth shape and a concave shape in a constant state, provided the vibration can be transmitted.

Moreover, the invention of claim 5 is a liquid-drop spraying device in which the vibration transmitting surface of the vibration source is smooth, the vibration transmitted surface of the pressure room is a thin walled portion projecting toward outside. It will be good that the pressure room equipped with a thin walled portion projecting toward outside is formed at the same time when the liquid sump including the pressure room is formed, and it will be also good that a projecting object is formed by adhesion and the like on a predetermined location of the vibration transmitted surface after forming the liquid sump.

Moreover, the invention of claim 6 is a liquid-drop spraying device in which at least one of contact surfaces where the vibration source and the pass are contacted with each other

is in a convex shape. Owing to this, change of the volume due to increasing and reducing pressure of the pass by the vibration source disperses to a plurality of volume reduction sections via inlet and causes a droplet to discharge.

Now, although a shape of pressure section of the vibration source is appropriately defined by a shape of a pass 20, it is not necessarily limited to a shape for pressurizing the entire area of a pass. Concretely, it will be good that only center portion out of the thin walled section located upper of the pass is contacted, in the case where a plurality of passes exist, it will be also good that all of the passes are pressurized. It will be also good that only part of the partial pass is pressurized considering distance from the inlet and it is selected according to the discharging efficiency, dimensions, shape and the like.

Moreover, the invention of claim 7 is a liquid-drop spraying device in which bridge portion between the pressure rooms is contacted with the vibration source. Now, it will be good that in the case where at least one of the contact surfaces is in a convex shape toward outside, the other is in any shape of a convex shape, a smooth shape and a concave shape. Particularly, in the case where a thin walled portion of the pressure room is formed in a concave shape to the bridge portion, when the flat vibration source pressures the bridge portion once, the bridge portion shifts to the pressure direction and the central portion shifts to the contrary of the pressure direction with respect to an end portion of thin walled portion in a concave shape, and then the volume of the pressure room increases and

the liquid is supplied from the pass. And, as the pressuring of the vibration source is completed, the pressure room returns to the original state and when the volume decreases, the liquid is discharged from the outlet, and by repeating this, the liquid becomes in a spraying state. Owing to this, the bridging portion has a thickness to the direction of increasing and reducing the pressure of the vibration plate compared to the thin walled portion, therefore, the bridging portion is more excellent than the thin walled portion in durability. Besides this, forming the thin walled portion in a concave shape indicates that if it is in a convex shape, it requires a step of making the height of the convex be certain level, while the height of the bridge portion is the same with the thickness of the entire device, therefore, it is easy to make the substrate with the thin walled portion in a convex shape and the number of making steps is reduced. It should be noted that when the bridging portion is pressured by the vibration source and an end portion of the thin walled portion in a concave shape shifts to the direction of pressuring, the bottom portion with respect to the thin walled portion of the pressure room requires a thickness not to shifted, and the amount of thickness is needed to appropriately adjust by material, mixing rate, the length, width and thickness of the bridging portion. Moreover, by adjusting the dimensions, shapes and the like of the pressure room and the bridge portion, it can be also designed so that the volume / capacity of the pressure room is reduced when pressuring. For example, in the case where the width of the bridge portion is sufficiently narrowed with respect to the pressure room, or in the case where the side face of the pressure room is formed diagonally with respect to the upper

surface or the bottom surface, the upper surface and the bottom surface are deformed in parallel so that the total thickness of the entire device is reduced, thereby reducing the volume and the like of the pressuring room and discharging the liquid.

Moreover, the invention of claim 8 is a method of manufacturing a liquid-drop spraying device in which after a liquid sump consisted of the pressure room having at least one discharging outlet and the pass connected to one or more pressure rooms via an inlet and supplying a liquid, and the vibration source causing the relevant liquid sump to change the volume are separately formed, the liquid sump and the vibration source are integrated so that vibration of the relevant vibration source is transmitted to the relevant liquid sump, then two or more relevant pressure rooms are provided with respect to the relevant vibration source. Owing to this, since the vibration source and the liquid sump can be formed by different materials and steps, for example, the vibration source can formed by a material enlarging an amount of displacement and being different from the material of the liquid sump which has been sintered, and the material of the liquid sump can be a metal having a high toughness and durability. Then, since the material component forming the vibration source does not diffuse to the substrate having the liquid sump, the material of the substrate becomes stable and its durability can be more enhanced, and furthermore, the liquid sump and the vibration source can be individually checked, and reliability is more secured.

~~Brief Description of the Drawings~~

FIG. 1 is a vertical sectional view of a discharging unit of a liquid-drop spraying device;

FIG. 2 is an illustration showing the other liquid-drop spraying device;

FIG. 3 is an illustration showing the other liquid drop spraying device;

FIG. 4 is a perspective view showing the liquid-drop spraying device of FIG. 3; and

FIG. 5 is an illustration showing the other liquid-drop spraying device.

Description of references

1 DISCHARGING UNIT OF LIQUID DROP SPRAYING DEVICE,
10 PRESSURE ROOM,
10a THIN WALLED PORTION,
11 DISCHARGING OUTLET,
11a NOZZLE HOLE,
12 INLET HOLE,
13 VIBRATION SOURCE,
13a PIEZO ELECTRIC / ELECTROSTRICTION ELEMENT,
13b ACTUATOR,
14 BRIDGING PORTION,
15 ELECTRODE,
20 PASS.

Best Mode for Carrying Out the Invention

The mode for carrying out a liquid-drop spraying device of the present invention will be described in detail below.

FIG. 1 is a vertical sectional view of a discharging unit 1 of a liquid-drop spraying device. The pressure room 10 discharging a liquid-drop due to the reduction of the volume of the liquid sump provides the discharging outlet 11 having the nozzle hole 11a which is opened outwardly in a lower portion of an end, provides the inlet hole 12 on the other end of the surface where the discharging outlet 11 is provided, and the relevant pressure room 10 is connected to the pass 20 via the inlet hole 12. Moreover, on the upper wall portion of the pressure room 10, the vibration source 13 is integrally provided and mounted in a transverse direction so as to range over the upper wall portions of the other pressure rooms 10 transversely arranged in parallel. The vibration source 13 is the piezo-electric / electrostrictive element 13a laminating the upper portion electrode, the piezo-electric / electrostrictive layer and the lower portion electrode, by applying a predetermined voltage signal to the piezo-electric / electrostrictive element, the piezo-electric / electrostrictive element is deformed by electric field generated between the upper portion electrode and the lower portion electrode, by deforming the wall portions of the mounted multiple pressure rooms 10 at the same time, a liquid supplied to the respective pressure rooms 10 are discharged from the discharging outlet 11 as a liquid-drop at the same time by pressurized force generated in respective pressure rooms 10. To the contrary, as the lower surface of the vibration source 13 rises upward to return to the original position, the thin walled portions 10a of the multiple pressure rooms 10 also return to the original shape at the same time, a liquid is supplied via the inlet hole

12 to the respective pressure room 10 from the pass 20 due to negative force generated in the respective pressure rooms 10 and the device prepares for the next ejection. A liquid-drop is ejected in a spraying state by repeating this.

FIG. 2 (a) is an illustration showing the other embodiment of FIG. 1. The pressure room 10 provides the discharging outlet 11 having the nozzle hole 11a which is opened outwardly in a lower portion of an end, provides the inlet hole 12 on the other end of the surface where the discharging outlet 11 is provided, and the relevant pressure room 10 is connected to the pass 20 via the inlet hole 12. Particularly, the thin walled portion 10a of the pressure room 10 is formed in a convex shape outwardly, and between this and the thin walled portion 10a of the other pressure room 10 located laterally, the concave portion is formed.

On the other hand, in the upper position of the upper wall portion of the pressure room 10, the vibration source 13 which is separately formed is equipped, the lower surface of the vibration source 13 is formed smoothly, in a usual state, the positional relationship of the lower surface and the thin walled portion 10a of the pressure room 10 being contacted with each other is kept. Moreover, the vibration source 13 is also formed in a longitudinal shape in a transverse direction so as to range over till the upper wall portion of the other pressure room 10 arrayed laterally in parallel.

The vibration source 13 is an actuator 13b laminating piezo-electric / electrostrictive elements and electrodes over a plurality of layers, and excellent in low voltage driving

ability and high displacement ability as a structure vibrating upward and downward. By applying a predetermined voltage signal to the actuator 13b, the lower surface of the vibration source 13 at the illustrated position is lowered, a liquid supplied to the respective pressure rooms 10 is discharged from the discharging outlet 11 as a liquid-drop at the same time, due to the pressurized force generated in the respective pressure rooms 10 by simultaneously deforming the thin walled portion 10a in a convex shape outwardly of the multiple pressure rooms 10. To the contrary, as the lower surface of the vibration source 13 rises upward to return to the original position, the thin walled portion 10a of the multiple pressure rooms 10 also returns to the original shape at the same time, a liquid is supplied via the inlet hole 12 to the respective pressure room 10 from the pass 20 due to negative force generated in the respective pressure rooms 10 and the device prepares for the next ejection. A liquid-drop is ejected in a spraying state by repeating this.

FIG. 2 (b) and (c) exemplify forms of the laminated actuators 13b utilizing longitudinal piezo-electric effect and transversal piezo-electric effect, respectively, and are selected corresponding to required drive voltage, amount of displacement, shape and the like.

FIG. 3 and FIG. 4 are illustrations showing the other embodiment of FIG. 1 and FIG. 2. Although the pressure room 10 provides the discharging outlet 11 having the nozzle hole 11a which is opened outwardly in a lower portion of an end, since in this embodiment, the relevant pressure room provides the inlet hole 12 on the upper surface of the other end of the surface

where the discharging outlet 11 is provided and the relevant pressure room is connected to the pass 20 via the inlet hole 12, the pass 20 is located in more upper position than that of the pressure room 10, it is formed in the positional relationship closer to the upper surface of the discharging unit 1.

On the other hand, above the upper wall portion of the pressure room 10, the vibration source 13 separately formed and fixed partially on the base frame is equipped, the lower surface which is to be a movable section of the vibration source 13 and the thin walled portion 10a are formed in a smoothed manner.

FIG. 1 is a perspective view showing the positional relationship between the vibration source 13 and the pass 20. A pair of the pressure rooms 10, 10 shown in FIG. 3 are transversely arrayed in parallel, above which the vibration source 13 is located and formed in a longitudinal shape along the longitudinal direction of the pass 20 connecting to the multiple pressure rooms 10.

The vibration source 13 has also a structure for vibrating upward and downward as the actuator 13b, by applying a predetermined voltage signal, the position shown in FIG of the lower surface of the vibration source 13 is lowered with respect to the base frame on which it is mounted, causing the pass 20 to deform, the supplied liquid is discharged from the discharging outlet 11 of the respective pressure room 10 as a liquid-drop at the same time by conveying the liquid to the respective pressure rooms 10 simultaneously due to the pressurized force generated in the pass 20. To the contrary, as the lower surface of the vibration source 13 rises upward to return to the original position, the pass 20 also returns to original sharp and a liquid

is supplied to the pass 20 due to negative force and the device prepares for the next ejection. A liquid-drop is ejected in a spraying manner by repeating this.

FIG. 5 is also an illustration showing the other embodiment. The pressure room 10 provides the discharging outlet 11 having the nozzle hole 11a which is opened outwardly in a lower portion of an end, provides the inlet hole 12 on the other end of the surface where the discharging outlet 11 is provided, and the relevant pressure room 10 is connected to the pass 20 via the inlet hole 12. Particularly, the thin walled portion 10a of the pressure room 10 is formed in a convex shape inwardly, and the bridging portion located between this and the thin walled portion 10a of the other pressure room 10 located laterally, is formed in the positional relationship of a relatively projecting outwardly. Then, over the upper wall portion of the pressure room 10, the vibration source 13 which is separately formed and its lower surface is formed in a smoothed manner is equipped, in FIG. 5 (a) showing a usual state, the positional relationship of the lower surface and the upper surface 14 a of the bridging portion 14 being contacted with each other is kept. Moreover, the vibration source 13 is also formed in a longitudinal shape in a transverse direction so as to range over till the upper wall portion of the other pressure rooms 10 transversely arrayed in parallel.

The vibration source 13 also has a structure for vibrating upward and downward as the actuator 13b, by applying a predetermined voltage signal, the lower surface of the vibration source 13 is lowered to the position shown in FIG.5 (b), the

bridging portion 14 between the multiple pressure rooms 10 is deformed downwardly at the same time, a liquid is supplied from the pass 20 to the respective pressure rooms 10 due to the negative force generated by the respective pressure rooms 10 being rectangularly deformed. To the contrary, as the lower surface of the vibration source 13 rises upward to return to the original position, the bridging portion 14 also returns to the original shape at the same time and a liquid supplied to the respective pressure room 10 is discharged from the discharging outlet 11 as a liquid-drop at the same time due to the pressurized force generated in the respective pressure rooms 10. A liquid-drop is ejected in a spraying manner by repeating this.

The industrial application probability

As described above, according to the invention of claim 1, since at least two pressure rooms connected to at least one discharging outlet are provided with respect to the vibration source of a liquid-drop spraying device, not only discharging en bloc from a plurality of discharging outlets can be performed only by driving a vibration source, but also the width of the design can be broadened compared to the conventional ones and can generate a larger displacement since the vibration source itself is larger and uses other kinds of materials, thereby resulted in being capable of spraying a large amount.

Moreover, the invention of claim 2 is a liquid-drop spraying device in which the liquid sump and the vibration source are separate bodies. Owing to this, in addition to the above described effects, the vibration source and the liquid sump can

be separately formed, for example, the vibration source is capable of being formed by the materials enlarging displacement amount and separately from the liquid sump. Moreover, in the case where materials for the liquid sump is defined, for example, to be a metal, the toughness is enhanced and the durability can be enhanced. Then, since the material components forming the vibration source does not diffuses to the side of the substrate having a liquid sump, the material of the substrate becomes stable and the durability is more enhanced.

Moreover, the invention of claim 3 is a liquid-drop spraying device in which one of the portions of the vibration source is fixed on the fixation section of the base frame and the like, at least one of the portions out of the other vibration section or movable section is contacted with the liquid sump. Owing to this, the vibration of the vibration source does not transmits to the fixation portion side, and more efficiently transmits to the liquid sump and the spraying efficiency is enhanced.

Moreover, the invention of claim 4 is a liquid-drop spraying device in which the vibration source and the pressure room are contacted with each other, and at least one of the contacted surfaces is in a convex shape. Since many kinds of shapes of contacted surfaces can be utilized, it can be selected corresponding to the materials of the liquid sump and the vibration source, discharging amount and the like, discharging has been stable.

Moreover, the invention of claim 5 is a liquid drop spraying device in which the vibration transmission surface of the vibration source of claim 3 is smoothed, and the vibration submitted transmission surface of the pressure room is a thin walled portion projecting outwardly. Since the pressure room having a thin walled portion projecting outwardly can be easily prepared by utilizing a method of forming a conventional integrated projecting unit, the cost of preparation can be reduced.

Moreover, the invention of claim 6 is a liquid-drop spraying device in which the vibration source and the relevant pass are contacted with each other, at least one of the contacted surfaces is in a convex shape. Owing to this, the volume change due to the increasing and reducing pressure to the pass by the vibration source is dispersed into a plurality of volume reduction section via an inlet hole, discharging of the liquid-drop is performed, it is not necessary to mount a large number of vibration sources individually as the conventional ones, and the cost of preparation can be reduced.

Moreover, the invention of claim 7 is a liquid-drop spraying device in which the bridging portion between the pressure rooms is contacted with the vibration source. Owing to this, the bridging portion has a thickness larger than that of the thin walled portion with respect to the direction of increasing and reducing pressure of the vibration plate and is excellent in the durability and in addition, forming the thin walled portion in a concave shape, compared to the case where

it is in a convex sharp and required a step of making the height of the convex be certain level, indicates that since the height of the bridging portion is the same with the thickness of the entire device, it is easy to make the substrate and the number of steps is also reduced.

Moreover, the invention of claim 8 is a method of manufacturing a liquid-drop spraying device in which after a liquid sump and the vibration source are separately formed, two or more relevant pressure rooms are provided with respect to the relevant vibration sources by integrating the liquid sump and the vibration source so that vibration of the relevant vibration source is transmitted to the relevant liquid sump. Owing to this, since the vibration source and the liquid sump can be formed by different materials and steps, for example, the vibration source can be formed by a material enlarging an amount of displacement and separately from the conventional sintering material of liquid sump, and the material of the liquid sump can be a metal having a high toughness and durability. Then, since the material component forming the vibration source does not diffuse to the side of the substrate having a liquid sump by reduction of contact area, the material of the substrate becomes stable and its durability can be more enhanced, and furthermore, the liquid sump and the vibration source can be individually checked, and reliability is more secured.